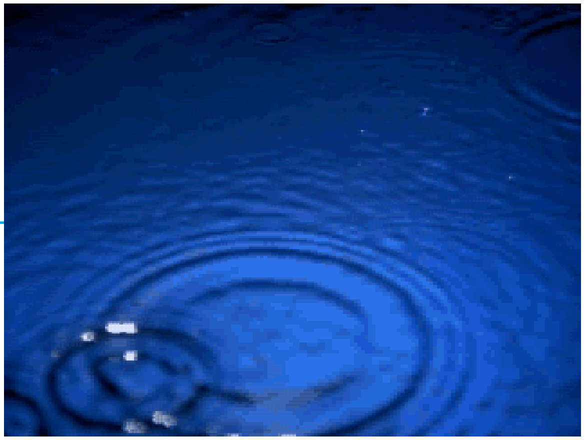
GPM

GLOBAL PRECIPITATION MEASUREMENT

Global Precipitation Measurement

System Definition Review

Core Spacecraft Management



December 6-8, 2005

Steve Horowitz 301/286-4620

Steven.J.Horowitz@nasa.gov

Goddard Space Flight Center

Core Spacecraft Presentation Outline

- GPM Core Spacecraft Hybrid Overview
- Implementation Approach
- Integration and Test
- Hybrid Spacecraft Acquisition Approach
- Hybrid Design Philosophy/Design for Demise
- Documentation
- Schedule
- Challenges/Risks
- Road to PDR
- Status

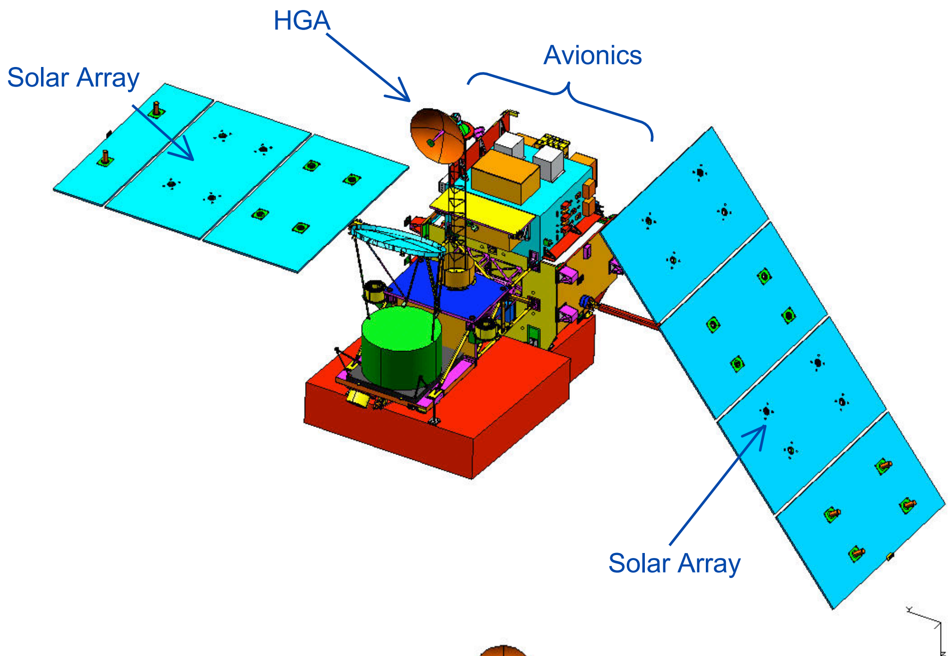
Changes Since SRR

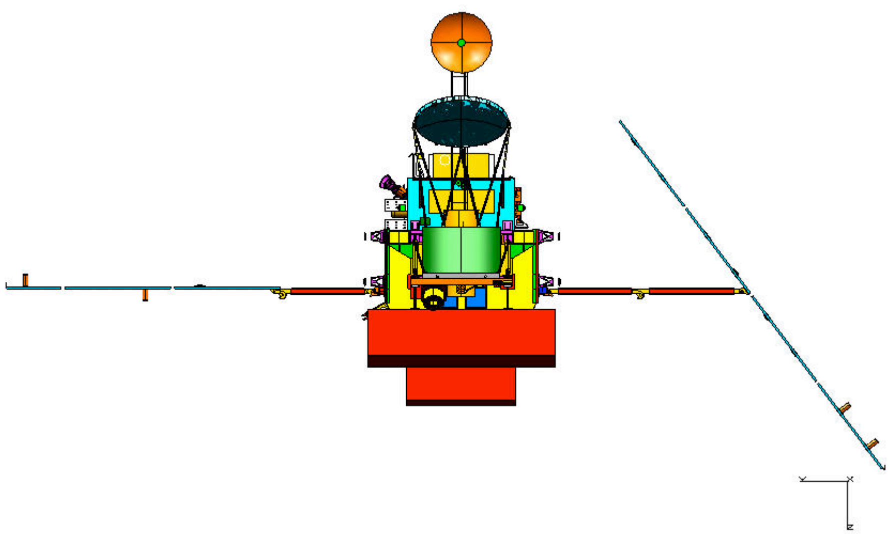
- ***At SRR the GPM Core Observatory was a full in-house development***
- ***On October 5, 2005 HQ approved switching to a Hybrid development approach, part in-house development, part out-of-house procurements through RSDO***
- ***GPM Core Observatory requirements have not changed***

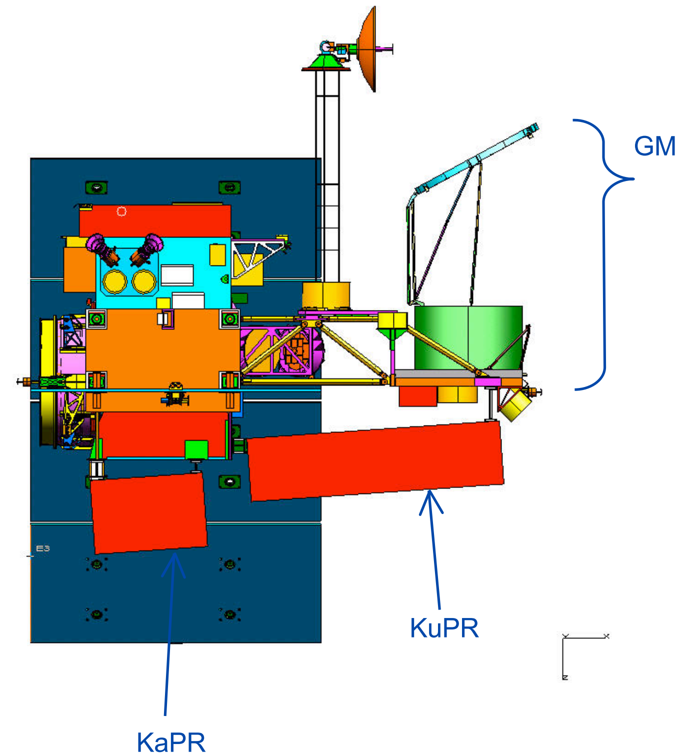
GPM Core Spacecraft Hybrid Overview

- **The Hybrid Approach is a combination in-house GSFC development and component procurement through RSDO**
- **Why the Hybrid approach**
  - Provides substantive in-house work for a variety of technical disciplines maintaining GSFC core competencies and training engineers
  - New development hardware provided by GSFC
    - Allows for new application of technologies to be developed and incorporated onto GPM
    - New development hardware is inherently more difficult to estimate cost and schedule and hence a fixed price contract is not the best procurement vehicle
  - Takes advantage of best features of the RSDO procurement process
    - Speed of procurement
    - Minimize cost
    - Minimize changes to "Off the shelf" hardware and software
  - Two Phase Acquisition Approach
    - A multi-vendor Avionics Package Study
    - Implementation Contract

GPM Observatory Deployed

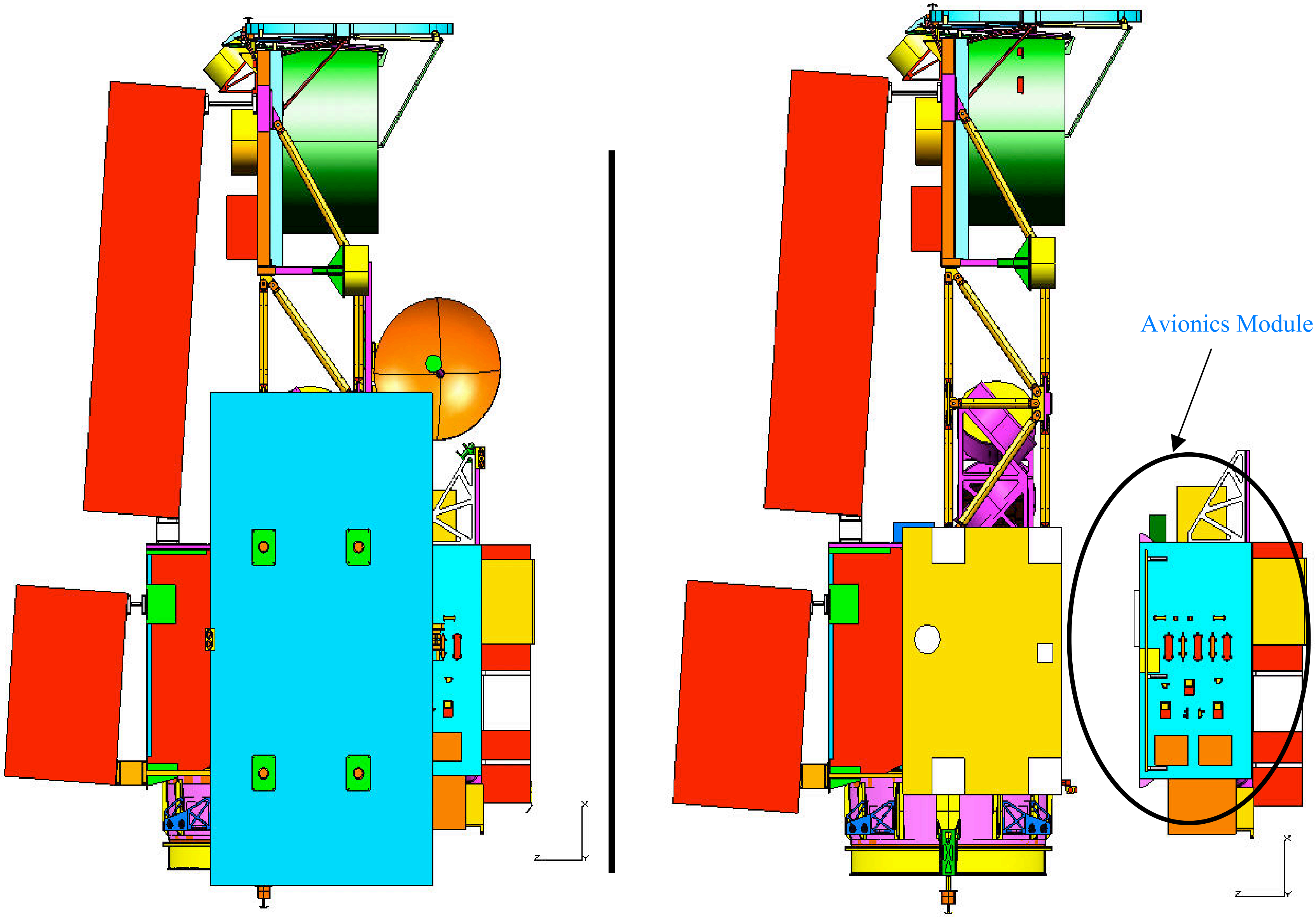




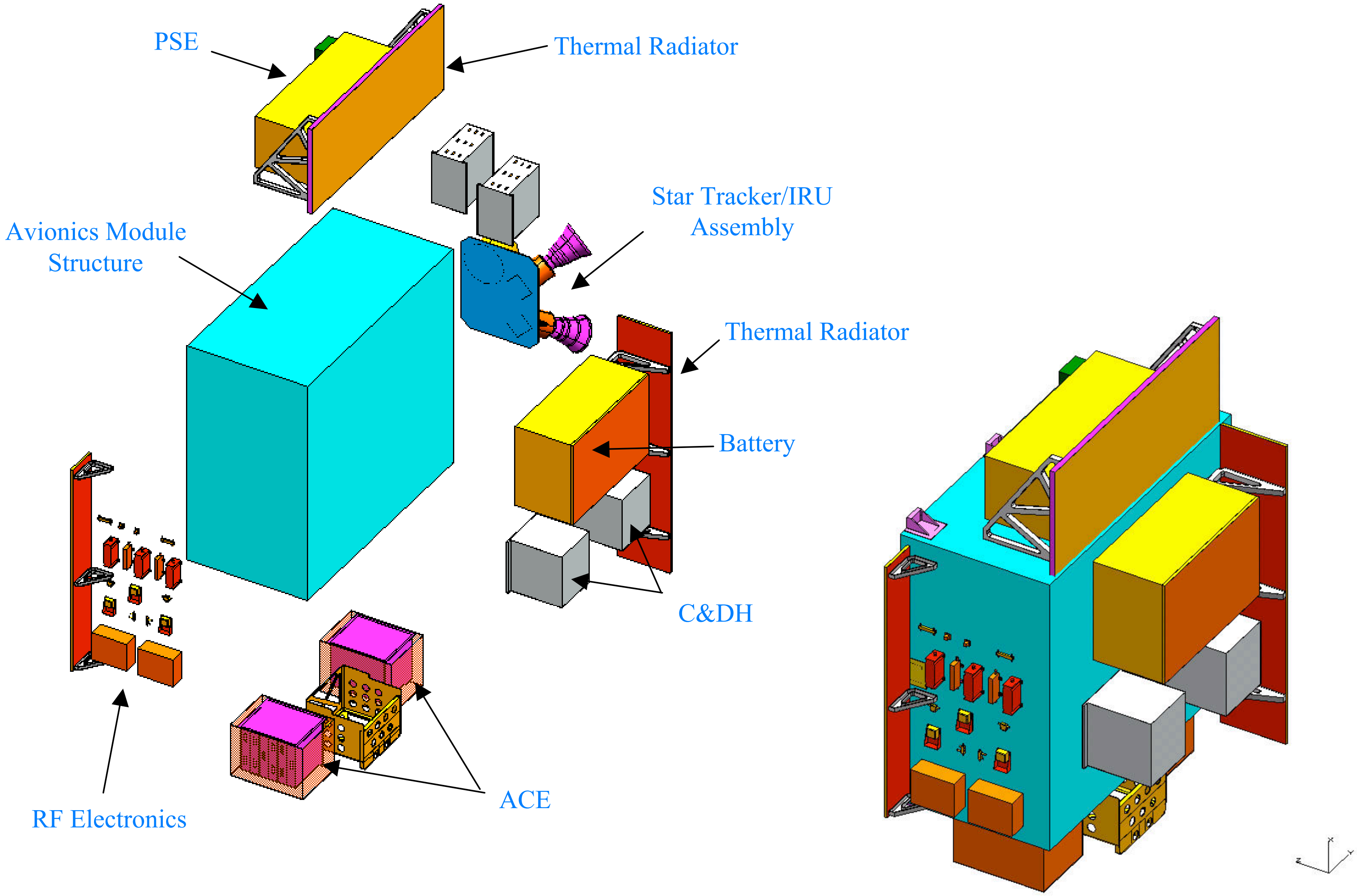


GPM Core Spacecraft Stowed

Solar Arrays Removed for Clarity

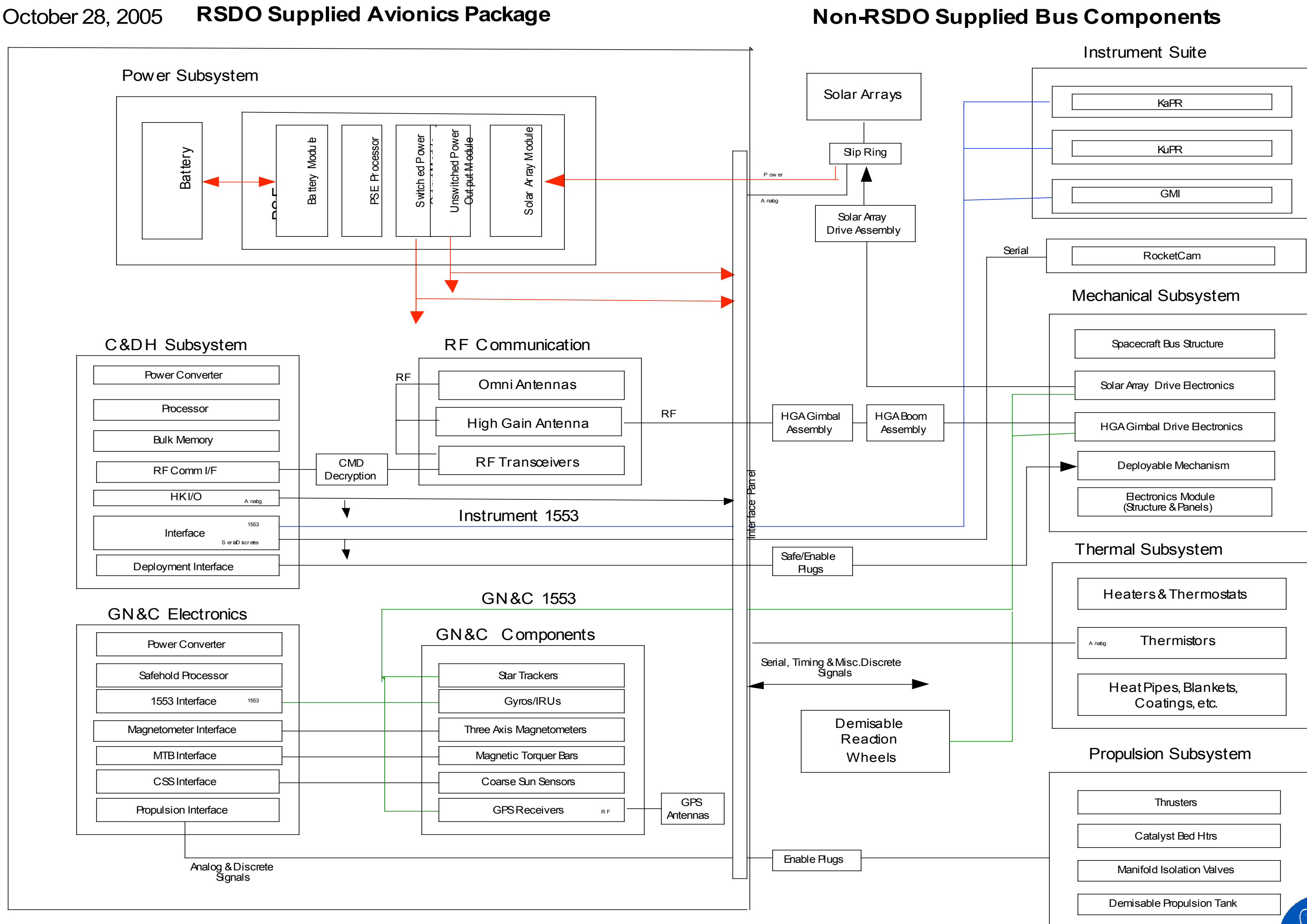


Avionics Module – Exploded View



Notional GPM Hybrid System Block Diagram

Revision 1.8.2
October 28, 2005



GPM Hybrid Core S/C Organization Chart

- WBS 378289.06.01 — **Observatory Manager** Steve Horowitz
  - **Lead for Avionics Package**-TBS
  - **Avionics Package Contractor**
  - WBS 378289.03 — **SAM** Tom Toutsi
    - **Safety** - Jamie Burget, Jim Anderson
    - **Reliability** - Lydia Lee, Nino Ingegneri
    - **EEE Parts** - Rich Williams
    - **Materials** - Chuck Powers
    - **Software Assurance** - Gary Jordan
    - **Quality Assurance** - Ed Mitchell
    - **Contamination** - Larry Ramsey
  - WBS 378289.02 — **Systems Group** Debbie O'Neill
    - **Mechanical Systems** - Pete Patterson
    - **Requirements** - Judy Brennan
  - WBS 378289.06.01 — **I & T Group** Tom Feild
    - **Deputy I&T Manager** – TBS
    - **EGSE** - Andy Aylward
    - **Test Conductors** - TBS
  - WBS 378289.06.02 — **GNC** Tim Gruner
    - **RWA** - Eli Ahronvich, Russell Roder, Linh Nguyen, Joe Vitale, Joe Romen
    - **Analysis** - TBS, TBS
  - WBS 378289.06.03 — **RF Comm** Maria Lecha
    - **HGAS** - Freeman Blackwell
  - WBS 378289.06.04 — **C&DH** Terry Smith
  - WBS 378289.06.08 — **Power** Tom Spitzer
    - **Solar Array** - TBS
  - WBS 378289.06.05 — **Software** Carver Audain
    - **Software Engineer** - TBS
  - WBS 378289.06.10 — **Electrical** Tin Lee
  - WBS 378289.06.06 — **Thermal** Greg Greer
    - **Spacecraft** - Walt Ancarrow
    - **Instrument I/F** - TBS
  - WBS 378289.06.11 — **Propulsion** Mike Rhee
    - Bob Estes
    - Sameer Garg
    - Khary Parker
  - WBS 378289.06.07 — **Mechanical** Jay Parker
    - **Spacecraft Structures** - Alexia Lyons
    - **Deployables** - Alphonso Stewart
    - **Prop. Module/Upper Bus Structure** – Larry Madison
    - **Mass Properties, MGSE** - Daniel Alvarado
    - **Lead Analyst** - Ryan Simmons
    - **Lead Stress Analyst** - TBS, Vanessa Marquez, Miguel Palanco
    - **HGAS Lead** - Chris Strickland, Victor Lo
    - **Instrument I/F-Analyst** - Larry Mignosa
    - **Analyst** - Terry Fan
    - **Lead Designer** - Bryan Grammer
    - **Prop. Module** - Rich Disorbo
    - **Upper Bus Structure** - Danny Grove
    - **Tooling Designer** – Vince Canali

GPM Hybrid S/C Implementation- GSFC Activities

- ***GSFC will develop:***
  - *Spacecraft system engineering*
    - *End-to-end requirements verification*
    - *System level and end-to-end testing*
    - *System thermal design*
    - *System mechanical design*
    - *Budgets*
      - *Mass, power, data rate, pointing, demise, RF link margins, etc.*
    - *IV&V*
  - *structure*
  - *thermal, external mounting interface*
  - *harness (not associated with inter-Avionics Package (AP) connections)*
  - *high gain antenna boom and actuators*
  - *solar arrays, solar array drive electronics*
  - *demisable reaction wheels*
  - *and the demisable propulsion subsystem*
- ***GSFC will provide engineering and oversight for the following:***
  - *Systems-level GN&C including RWA development*
  - *Systems-level Power including solar array procurement*
  - *Systems-level RF Communications*
  - *Systems-level C&DH including failure detection and correction*

GPM Hybrid S/C Implementation- GSFC Activities

- ***Details for Implementation relationships between GPM Project, AETD, other GSFC organizations, and AP contactor will be finalized during the AP Study***
  - *Agreements between GPM Project and AETD will be documented in an Implementation Plan for each subsystem (more information will be provided during the SDR Programmatic presentation)*
  - *Agreements between GSFC and AP contractor will be documented in the AP Implementation Contract*
- ***GSFC will be responsible for interface definition of Avionics Package (AP) and the spacecraft (mechanical, electrical, thermal, etc.) with appropriate coordination with AP vendor***
- ***GSFC will be responsible for Observatory I&T and launch operations***
- ***Much interaction between GSFC and AP vendor engineers will be necessary***
  - *Technical Interface Meetings*
  - *Video and teleconferences*
  - *GSFC engineers support AP contractor testing*
  - *AP engineers support of Observatory I&T, launch operations*

GPM Hybrid Spacecraft Management Approach

- ***The in-house team is in place and is ramping up consistent with GPM S/C PDR in August 2006:***
  - *FY06 - 32 FTE, 23 Civil Servants, 9 Contractor*
  - *Key personnel co-located with GPM Project*
  - *TBS's on organization chart will be phased in as appropriate*

Avionics Package - Key Features

- *Avionics Package configuration and GSFC interaction*
- *Avionics Module (AM)*
- *AP Test Program*
- *Transition from Vendor led AP test program to GSFC led Observatory I&T*
- *Simulators*

AP - Key Features - Configuration & GSFC Interaction

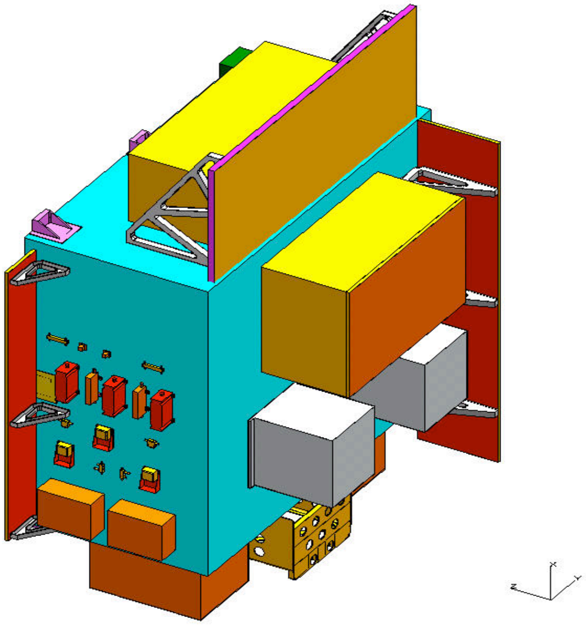
- ***The Avionics Package will be procured using RSDO. The envisioned AP consists of the following subsystems:***
  - *FSW,*
  - *GN&C,*
  - *C&DH,*
  - *Power,*
  - *RF Comm,*
  - *and AP interconnecting harness*

- ***Much interaction between GSFC and AP vendor engineers will be necessary***
  - *Technical Interface Meetings*
  - *Video and teleconferences*
  - *GSFC engineers support AP contractor testing*
  - *AP engineers support of Observatory I&T*

Avionics Package - Key Features- Avionics Module

- ***Avionics Package (AP): Subsystem components integrated on an Avionics Module Structure (AMS) plus individually mounted components (e.g., sun sensors, star trackers, high gain antenna).***
- ***Avionics Module (AM): An integrated module comprised of an Avionics Module Structure (AMS) and AP subsystem components.***
- ***Avionics Module Structure (AMS): A government provided structure designed for mounting AM components,***
- ***Avionics Module (AM) = AMS + integrated avionics components***
- ***Avionics Package (AP) = Avionics Module (AM) + individually mounted components***

Avionics Module



AP - Key Features - AM (cont.) and Test Program

- ***Avionics Module (AM) - GSFC will provide the flight AMS to the AP vendor***
  - *AMS will be a flight unit such that the AP can be delivered in flight configuration*
  - *GSFC will also provide an AM mockup*

- ***AP Test Program***
  - *Individual components will be qualified at box level as appropriate*
  - *Will include a qualification test program of the integrated Avionics Package on the flight AMS, e.g., EMI, thermal vacuum, (vibration at component-level)*
  - *Pre-ship Review at AP contractor after completion of all testing*
  - *The qualified AP fully integrated on the flight AMS (and government provided equipment such as heat pipes) will be delivered to GSFC*
  - *Government buyoff/DD250 occurs after shipment of AP to GSFC, successful completion of Acceptance Test at GSFC and review of acceptance data package*
  - *Ensures highest confidence that the AP meets all requirements*

AP - Key Features - I&T & Simulators

Transition from Vendor led AP test program to GSFC led Observatory I&T

- *GSFC will require necessary insight into vendor design and test to understand AP design sufficiently to lead Observatory I&T*
- *GSFC subsystem and test engineers will support testing at vendor*
- *After delivery of AP, vendor will support observatory I&T at GSFC*
- *An AP test bed will be located at the vendor facility*
- *FSW maintenance post-launch will be an AP vendor responsibility*
- *The AP vendor will support Observatory I&T under GSFC direction*

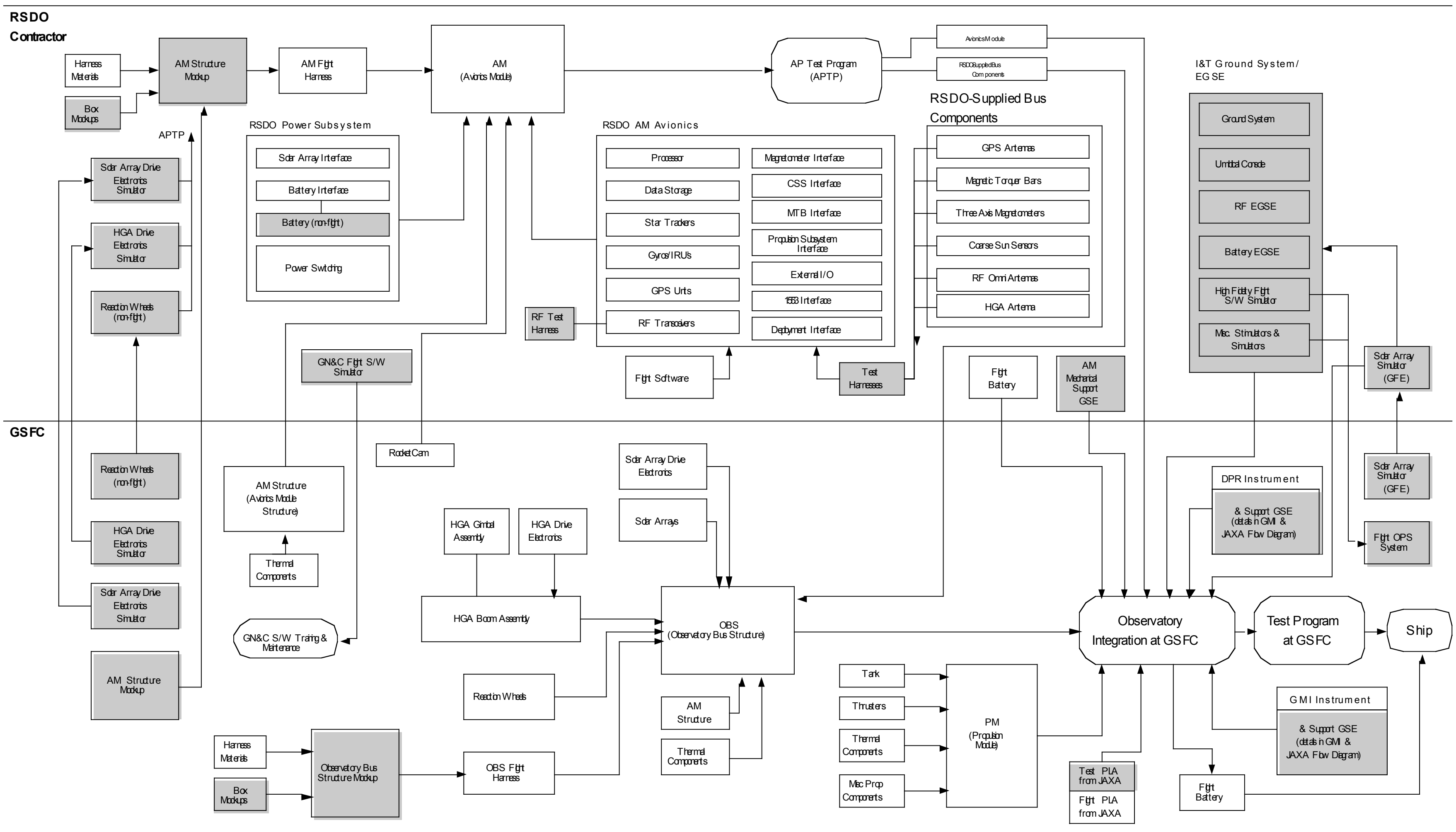
Simulators

- *Spacecraft Interface Simulator is to simulate the interfaces of the spacecraft so that the instrument developers can verify the interface prior to integration with the spacecraft*
- *Instrument Simulator is for the AP software provider to program and interface checkout prior to the delivery of the instruments*
- *Avionics Simulators that are needed for I&T are the GN&C Dynamic Simulator, the Battery EGSE, High Fidelity FSW Test Bench (FSTB), the I&T test GSE, the Umbilical Console and the RF EGSE*
- *The Solar Array Simulator will be provided by GSFC*
- *FSW test facility will reside at AP vendor throughout the mission lifetime*

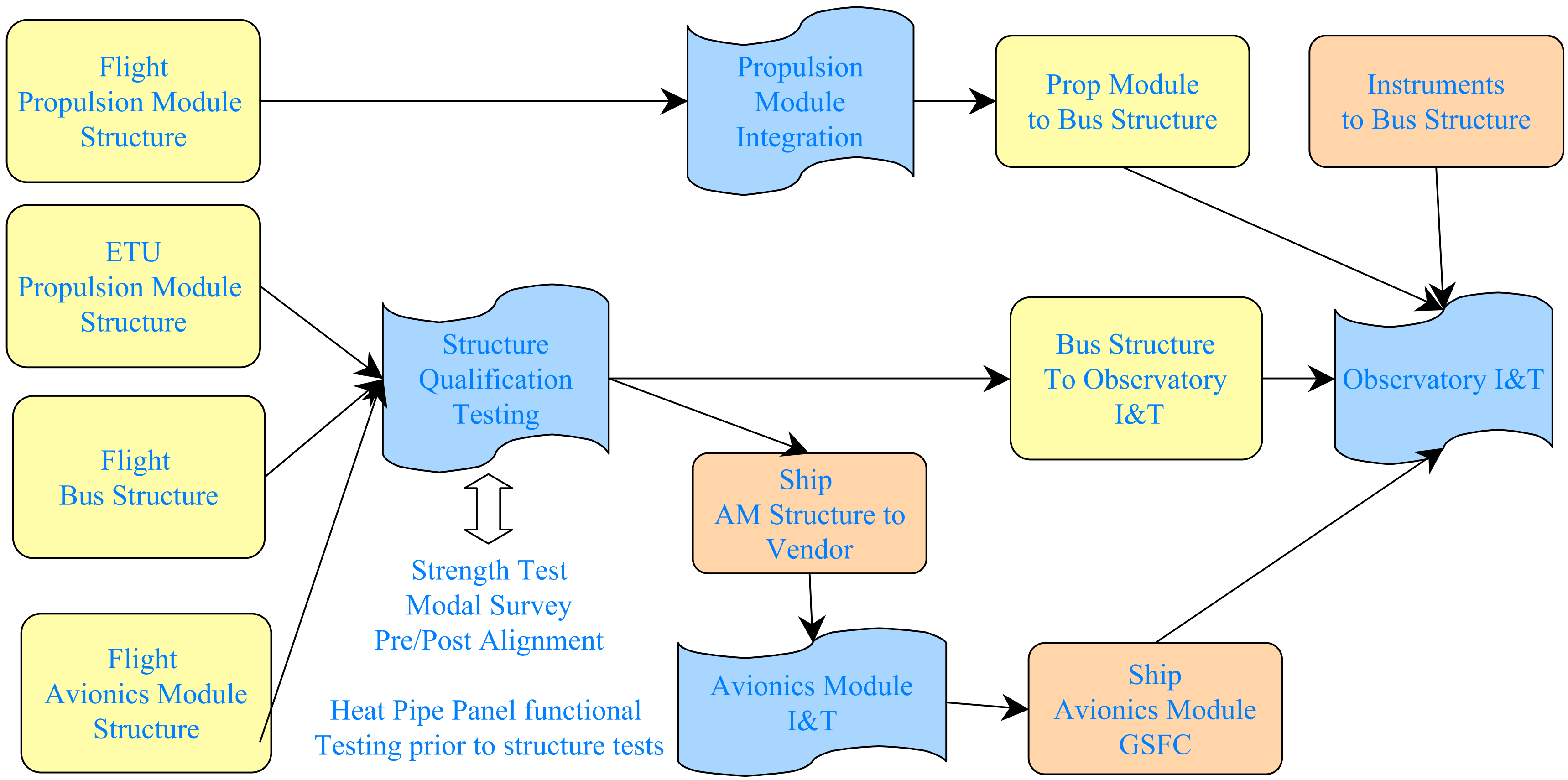
Core Observatory Flow Diagram

GPM Hybrid RSDO and GSFC Deliverables Flow Diagram
Revision 1.3-1
December 5, 2005

=Activity
=Non-Flight Hardware



GPM Core Observatory Integration and Test Flow - Avionics Integration



Color Codes for Flow charts:

Yellow: Internal Deliverables	Orange: External Deliverables & JAXA Tasks	Blue: Integration Activities	Green: Tests and Reviews

Hybrid Challenges

- ***The AP vendor has Avionics Package expertise, how does GSFC lead and manage a successful development, I&T, launch and operations programs?***
  - *1. Support for I&T at GSFC*
    - *GSFC test conductors and subsystem engineers will be trained at AP contractor's facility*
    - *AP contractor will support subsystem, observatory, and environmental testing at GSFC and the MOC*
  - *2. Performance test development*
    - *AP contractor database and procedures developed for integration and test activities will be transferred for re-use at GSFC*
    - *GSFC and AP contractor will study using a common ground system for AP testing, Observatory testing and Flight Ops*
  - *3. Ground Support Equipment*
    - *AP contractor will deliver custom GSE required to integrate and test the Avionics Package.*
  - *4. Flight Software maintenance*
    - *AP contractor responsible for maintaining FSW*
    - *FSW test facility will reside at AP vendor throughout the mission lifetime*
  - *5. Flight Avionics Module Structure(AMS)*
    - *GSFC will provide the flight AMS to AP contractor for integration and testing of Avionics Package*
    - *Allows for simplified government buyoff*
    - *Buyoff at integrated level*
    - *Ensures highest confidence that the AP meets all requirements*

GPM Hybrid Spacecraft Acquisition Approach

- ***Background - Out of house Study #1 for RSDO spacecraft***
  - *Completed November 2004*
  - *Requested a ROM estimate for the Avionics Package*
  - *Size, weight, power, cost provided*
  - *All three Study #1 AP designs met GPM requirements*
  - *GPM in-house work to date envelopes worst case design*

- ***Hybrid Acquisition Approach***
  - *Avionics Package RFI - received November 3, 2005*
  - *Multi vendor Avionics Package study - January 2006 - August 2006*
  - *Avionics Design Review (ADR) - June 2006*
  - *Select AP vendor - July 2006*
  - *Spacecraft PDR - August 2006*

Avionics Package Study

- ***Select up to two vendors for an Avionics Package study***
  - *January 2006 - August 2006*
- ***Study will investigate best approach for developing the Hybrid***
- ***The Study RFO provides the GPM Project's "baseline" Hybrid approach***
- ***An important part of the Study is to get vendor recommendations to the baseline. This includes division of hardware responsibilities, test program, etc.***
- ***Ground rules for the AP Study***
  - *Minimize changes to existing AP design*
  - *Minimize impacts to cost and schedule*
  - *Maintain a simplified government buyoff of the Avionics Package*
  - *The Study results will be presented at an Avionics Design Review - June 2006*
  - *Post ADR study activities include support of GPM Project in preparation for Mission PDR (August 2006)*
- ***Implementation Phase RFO to be released concurrent with ADR***

GPM Hybrid Spacecraft Design Features

- ***Design for Demise***
  - *Advantages:*
  - *Inherently more reliable than controlled reentry*
  - *Enables maximum use of spacecraft resources*
    - *No mass allocation for controlled reentry*
    - *No unique hardware for de-orbit*
    - *No early reentry due to reliability risk – operate spacecraft to the bitter end as spacecraft components gracefully degrade - unlike GRO*
  - *Avoids operations costs associated with controlled reentry*
  - *Avoids inefficiencies of prolonged reentry decision making process (TRMM)*
- ***Challenges:***
  - *Standard designs for prop tanks and reaction wheels utilize Ti and Stainless Steel, respectively*
  - *Ti utilized in structural components – alternatives are not as mass efficient*
  - *More extensive de-orbit analyses to ensure demise compliance*
  - *TRMM analysis shows the PR & TMI comply with this philosophy*
- ***GPM Core Observatory requirement - Debris Casualty Area (DCA) < 8m2***
  - *GPM estimate with demisable technologies - 4.4 m2*
  - *GPM estimate without demisable technologies- >20 m2*
- ***GPM is baselining the following new applications of materials: Demisable propellant tank, demisable RWA, demiseable structural node fittings***

Demisable Tank Development (Continued)

- **Challenges**
  - Compatibility of aluminum PMD with Hydrazine fuel
    - First application of aluminum as a PMD material
    - Previous studies indicate special surface treatment is required to make aluminum work as a PMD
    - Comprehensive study underway to develop treatment process

- **Schedule**
  - Compatibility study: 11/1/2005 to 4/15/2006
  - Tank SOW/Specification Release: 5/1/2006
  - Tank contract award: 6/1/2006
    - Expecting 22 months program including full qualification effort
    - Flight units will be delivered in 16 months
  - Expected flight unit delivery: January 2008
  - Schedule shows propulsion I&T beginning in August 2008

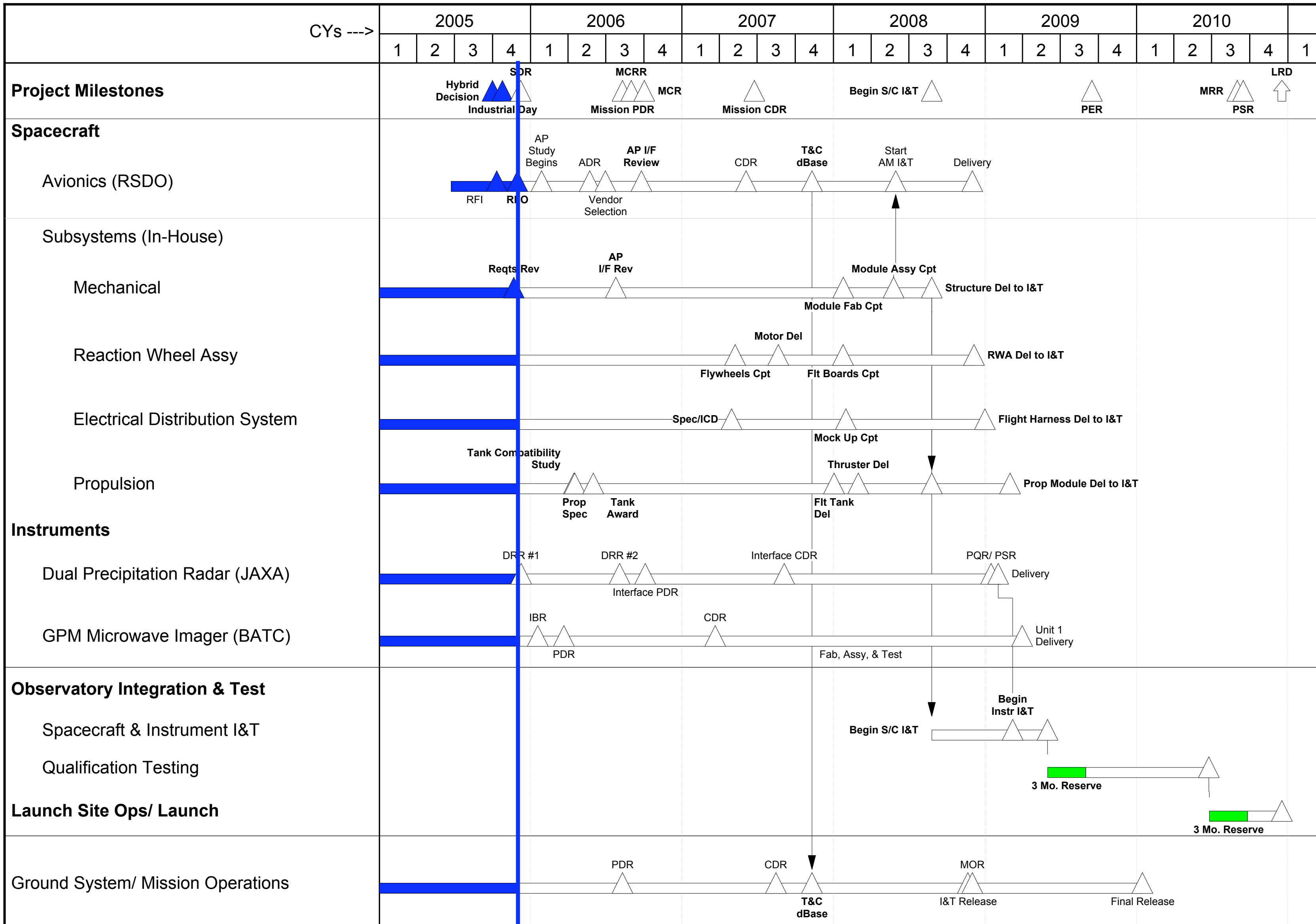
GPM Demisable RWA Status

- ***Demisable RWA ETU Status***
  - *EMC testing completed during the first week of November 2005*
  - *The ETU wheel is in final preparation for vibration testing*
  - *All redesigned mechanical parts on order, delivery is schedule for first week of December 2005*
  - *Complete reassembly and pre-vibration testing by December 22, 2005*
  - *Vibration testing is being scheduled for the end of December 2005*
- ***Flight Wheels Schedule***
  - *Peer review April 2006*
  - *Start procurement January 2007*
  - *Deliver four flight wheels January 2009*
    - *Schedule shows Spacecraft I&T start in the first quarter of 2009*
- ***Life test***
  - *Reaction wheel life test can start in July 2006*
    - *Provide 4.5 years of life testing prior to launch*

GPM

GPM Core Observatory Master Schedule

Baseline: 10/01/05
Status:11/30/05



GLOBAL PRECIPITATION MEASUREMENT

Risk Title

H-6 Hybrid Approach to Build Spacecraft

H-7 AP Acceptance

H-8 GFE Delivery to RSDO Vendor

H-9 Post AP Delivery Support

H-23 Spacecraft Testing in Thermal Vac

H-24 Hybrid I & T

		Impact				
		1	2	3	4	5
Probability	5					
	4		H-8			
	3		H-6 H-7			
	2			H-24		
	1		H-23		H-9	

Road to PDR

- ***Avionics Package Study, January 2006 - July 2006***
  - *Kickoff meeting with up to two vendors - January 2006*
  - *TIM #1, 6 weeks ARO*
  - *TIM #2, 10 weeks ARO*
  - *Weekly Teleconferences*
  - *As needed, video and teleconferences between GSFC and AP contractor engineers*
  - *Avionics Package Design Review (ADR) - June 2006*
- ***In-house subsystem peer reviews (i.e., RWA, Propulsion Tank, Mechanical) - April-June 2006***
- ***Core Spacecraft Preliminary Design Review - August 2006***
- ***GPM Mission PDR - August 2006***

Backup Slides

H-6: Hybrid Approach to Build Spacecraft

Risk Statement: Given that the hybrid approach for GPM is the first of its kind; it is possible that the methodology used to procure the avionics package and build the spacecraft may overlook pertinent details, resulting in potential impact to the performance of the spacecraft and/or cost and schedule impacts.

Risk Data:
Level: Element (Core)

Probability \ Impact	A	B	C	D	E
E					
D					
C		X			
B					
A					

Owner: Steve Horowitz
Timeframe: Short-Term

Mitigation: Complete a study with the RSDO vendors to gather input and suggestions regarding the proposed methodology and timeline.

Include negotiated options in the Implementation Contract to enable the Project to task the contractor with items that may have been overlooked.

Contingency:

H-7: AP Acceptance

Risk Statement: Given that the hybrid approach includes acceptance of the avionics package (AP) and DD-250 signature prior to integration and test of the AP in the Core spacecraft for contractual reasons; it is possible that post acceptance design changes may be necessary, impacting cost and schedule.

Risk Data:
Level: Element (Core)

Probability \ Impact	A	B	C	D	E
E					
D					
C		X			
B					
A					

Owner: Steve Horowitz
Timeframe: Long-Term

Mitigation: Complete a study with the RSDO vendors to gather input and suggestions regarding AP test program and acceptance criteria.

Incorporate study results in the Implementation Contract.

Contingency:

GLOBAL PRECIPITATION MEASUREMENT

Day 2 - December 7, 2005
Location: NASA GSFC B16W-N76/80

Time	Section	Event	Presenter
8:30 AM	12	Core Spacecraft Management	Horowitz
9:30 AM	13	Primary Spacecraft Systems Engineering	O'Neill
11:00 AM		**Break**	
11:15 AM	14	Mission Operations System Concept/Requirements	Rykowski
12:15 PM		**Lunch**	
1:15 PM	15	Precipitation Processing System Concept/Requirements	Stocker
2:15 PM	16	Ground Validation	Schwaller
3:15 PM		**Break**	
3:30 PM	17	Risk Assessment	Durning
3:45 PM	18	Review Wrap Up	Durning/Ho
4:00 PM		Review Team Caucus	
4:15 PM		**End of Day 2**	